

Root parasitic nematodes in nursery plants imported to Finland in 1980

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Abstract. Injurious nematodes were found in 201 of the investigated 670 plant stocks of 42 imported consignments. Infections by quarantine nematodes appeared in 100 stocks of 26 consignments, 15 thereof including 3 or more infected plant stocks each.

Root knot nematode, *Meloidogyne* spp., appeared in 81 stocks, i.e. 12 % of the investigated material. The infections were found in 40 plant species, relatively often in barberry, *Berberis* sp., and in peony, *Paeonia* sp.. Among garden roses, 26 out of 167 stocks investigated were infected by root knot nematodes.

Root lesion nematode, *Pratylenchus penetrans* (Cobb) Chitwood & Oteifa, of *P. convalariae* Seinhorst was found in 28 plant stocks, i.e. 4 % of the investigated material. Several *Pratylenchus*-infected stocks were found among roses, raspberry and barberry.

Potato rot nematode, *Ditylenchus destructor* Thorne, was found in one rose stock and related *D. myceliophagus* J. B. Goodey in 12 stocks of various plants. Several ectoparasitic species were found in very low numbers. Virus vectors, *Trichodorus primitivus* (de Man) Micoletzky and *T. viruliferus* Hooper, were detected in a total of four stocks, but too few for virus transmission tests.

The transmissibility of the detected nematodes was discussed, and the risks of introduction of nematode pests to the country was re-assessed.

Introduction

Dispersal of nematode pests in the international market of plant material has repeatedly been reported (BINGEFORS 1967, BRAACH 1978, ESSER 1978). In the 1950's the introduction of the stem nematode, *Ditylenchus dipsaci* (Kuhn) Filipjev, and the sugarbeet nematode *Heterodera schachtii* Schmidt was associated with the import of their host plants to Finland (ROIVAINEN 1961, ROIVAINEN et al.

1962). Later, a few cases of introduced root knot nematodes, *Meloidogyne* sp., have appeared in greenhouse cultivations. In 1976—80, the import of nursery plants, especially roses, was prohibited on the basis of local phytosanitary regulations because of root knot nematodes (ANON. 1976—80).

In the Finnish quarantine regulations, *Ditylenchus destructor* Thorne, *Globodera pallida* Stone, *G. rostochiensis* Wollenweber,

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Radopholus similis (Cobb) Thorne, *Xiphinema americanum* Cobb, *D. dipsaci* and *Meloidogyne* spp. are included in the A2 list and *Bursaphelenchus xylophilus* (Steiner & Buhrer) Nickle together with *Nacobbus aberrans* (Thorne) Thorne & Allen in the A1 list. Imported material is supposed to be substantially free from these nematodes. The nematodes of which slight infections are accepted (B list) include *Aphelenchoides* spp., *Pratylenchus convallariae* Seinhorst, *P. penetrans* (Cobb) Chitwood & Oteifa and *P. vulnus* Allen & Jensen.

In 1975—80, plant propagation material for Finnish horticultural nurseries was imported mainly from Central Europe, particularly from the Netherlands, and occasionally from non-European countries (ANON. 1976—80). In the few surveys published on the growing areas of European nurseries, certain root parasitic nematodes, including *Meloidogyne* and *Pratylenchus* species occurred commonly (NOLTE and DIETER 1957, SONDERHOUSEN et al. 1968, KOZŁOWSKA and WASILEWSKA 1972, SALY 1979, COTTEN and ROBERTS 1981).

The objective of this survey on plant material imported to Finland in 1980 is to reveal the potential sources of nematode infections risky for nursery cultivation in the field as well as in greenhouses.

Materials and methods

Samples

Root samples were taken in April 1980 arbitrarily from the imported plant material by the quarantine officers performing routine plant inspection. The number of samples taken was 670, and each sample represented a uniform stock of imported plants. Samples were taken from 42 consignments, each sent by one exporter and including a minimum of 10 plant stocks. The consignments came from European countries: 17 from the Netherlands, 15 from Denmark, 7 from West Germany, 1 from Belgium, Sweden and United Kingdom,

each. (The total distribution of consignments from these countries in 1976—80 was 65 %, 18 %, 6 %, 4 %, 5 % and 2 %, respectively.) The size of the samples varied between 20—200 g, depending on the structure of the root system, big samples taken from roots with large diameter. The samples were transported in closed plastic bags.

Extraction and identification

In the laboratory of the Department of Agricultural and Forest Zoology, University of Helsinki, the uncleaned roots were cut or chopped into pieces of less than 0.5 cm in size and a subsample of 10 g was processed by the centrifugal flotation method (CAVEVESS and JENSEN 1955) and another subsample of 10 g on a mistifier apparatus (HOOPER 1970a) for five days to extract the nematodes. The nematodes were thereafter fixed in a mixture of formalin, triethanolamine and water (T.A.F.) (HOOPER 1970b). The total number of nematodes and the number of nematodes of the genera *Ditylenchus* spp., *Meloidogyne* spp., the spiral nematodes (*Helicotylenchus* spp., *Rotylenchus* spp.), *Tylenchorhynchus* spp., the trichodorid nematodes and the longidorid nematodes were counted. The identifications were done from subsamples mounted in glycerol by the Seinhorst slow method (HOOPER 1970b). Special attention was paid to species mentioned in the plant quarantine regulations issued in Finland. A sample was defined as infected if any of the above nematodes could be detected by either of the two extraction methods.

Results

Frequency of infections

Nematodes belonging to the genera *Ditylenchus*, *Meloidogyne*, *Pratylenchus*, *Helicotylenchus*, *Rotylenchus*, *Tylenchorhynchus* and *Trichodorus* were found in 201 of the 670 investigated root stocks. The number of infections specified in the quarantine regulations

was 115 in 100 stocks. The occurrence of infections in the most commonly imported plants is presented in Table 1. The infected plant stocks were distributed by consignments as follows: all plant stocks in a consignment free from any quarantine infections 16, one stock infected 4, two stocks infected 7, and 3 or more stocks infected 15 consignments (mean 3.8). (The consignments consisted a minimum of 10 plant stocks.)

Potato rot nematode

The plant parasitic *Ditylenchus* species was rarely encountered (Table 1). The only *D.*

destructor infection was found in rose stock (cv. Europaena) also infected by *Meloidogyne* spp.. No visible symptoms were seen in the infected roots. The other *Ditylenchus* species was *D. myceliophagus* J. B. Goodey which was found in 12 root stocks of the following plants:

<i>Ajuga reptans</i> L.	<i>Potentilla fruticosa</i> L.
<i>Aronia prunifolia</i> (Marsh.) Rehd.	<i>Prunus domestica</i> L.
<i>Clematis</i> × <i>jack-</i> <i>manii</i> T. Moore	<i>Prunus padus</i> L.
<i>Picea abies</i> L.	<i>Rosa</i> L. sp.

Table 1. Occurrence of infections of phytosanitarily important nematodes in the common plant genera imported to Finland in 1980.

Plant	No of stocks	Number of stocks infected by			
		D. des.	Mel.spp.	P. con.	P. pen. #
<i>Acer</i> L. sp.	20		1	1	
<i>Amelanchier</i> Medic. sp.	10				
<i>Astible</i> D.Don sp.	12				
<i>Berberis</i> L. sp.	18		7		3
<i>Caragana</i> Fabr. sp.	10				
<i>Cornus</i> L. sp.	10		1		
<i>Hemerocallis</i> L. sp. +					
<i>Convallariae</i> L. sp.	10		3	1	
<i>Hydrangea</i> L. sp.	11		2		
<i>Lonicera</i> L. sp.	10		1		
<i>Malus</i> Mill sp.	12		2		
<i>Paeonia</i> L. sp.	10		4		1
<i>Philadelphus</i> L. sp.	10		2		
<i>Phlox</i> L. sp.	10		1		
<i>Picea</i> A.Dietr. sp. +					
<i>Pinus</i> L. sp.	13		4		
<i>Potentilla</i> L. sp.	14		3		2
<i>Prunus</i> L. sp.	21		1		
<i>Rhododendron</i> L. sp.	10		2		
<i>Ribes</i> L. + <i>Rubus</i> L. sp.	37		5	2	3
<i>Rosa</i> L. sp.	167	1	26	5	5
<i>Salix</i> L. sp.	10				
<i>Spiraea</i> L. sp.	15		3		1
<i>Syringa</i> L. sp.	20		4		2
<i>Taxus</i> L. + <i>Thuja</i> L. sp.	10		3		
<i>Tilia</i> L. sp.	12		2		
<i>Rosa</i> L. sp. # #	40		4	1	1
Total	512	1	81	10	18

D. des. = *Ditylenchus destructor*

Mel. spp. = *Meloidogyne* spp.

P. con. = *Pratylenchus convallariae*

P. pen. = *P. penetrans*

roses for cut flower production (30) and for house plants (10)

Root knot nematodes

Meloidogyne infections occurred most frequently in the imported plant material (Table 1.). According to the juvenile morphology, the *Meloidogyne* species included *M. arenaria* (Neal) Chitwood, *M. graminicola* Golden & Birchfield, *M. hapla* Chitwood, *M. incognita* (Kofold & White) Chitwood, *M. javanica* (Treub) Chitwood and *M. naasi* Franklin. The relative frequency within species was not estimated. Juvenile root knot nematodes were found among the following plants:

<i>Acer platanoides</i> L.	<i>Pinus cembra</i> L.
<i>Aesculus hippocastanum</i> L.	<i>Populus</i> L. sp.
<i>Aronia prunifolia</i>	<i>Potentilla fruticosa</i>
<i>Berberis thunbergii</i> DC.	<i>Rhododendron</i> L. sp.
<i>Convallaria majalis</i> L.	<i>Rosa</i> sp.
<i>Cornus alba</i> L.	<i>Ribes alpinum</i> L.
<i>Hemerocallis</i> L. sp.	<i>R. nigrum</i> L.
<i>Humulus lupulus</i> L.	<i>R. pallidum</i> Otto & A. Dictr.
<i>Hydrangea paniculata</i> Sieb.	<i>Rubus idaeus</i> L.
<i>Juniperus communis</i> L.	<i>R. odoratus</i> L.
<i>Lonicera tatarica</i> L.	<i>Sorbaria sorbifolia</i> (L.) A.Br.
<i>Lychnis chalconica</i> L.	<i>Spiraea</i> L. sp.
<i>Malus baccata</i> (L.) Moench	<i>Syringa</i> L. sp.
<i>M. × domestica</i> Borkh.	<i>Symphoricarpos</i> Duham. sp.
<i>Paeonia officinalis</i> L.	<i>Taxus cuspidata</i> Sieb. & Zucc.
<i>Parthenocissus quinquefolia</i> (L.) Planch.	<i>Thuja occidentalis</i> L.
<i>Philadelphus coronarius</i> L.	<i>Tilia cordata</i> Mill.
<i>P. × virginialis</i> L.	<i>Vaccinium corymbosum</i> L.
<i>Phlox paniculata</i> L.	<i>Viburnum opulus</i> L.
<i>Physocarpus</i> (Cambess.) Maxim. sp.	
<i>Picea omorica</i> (Panc.) Purk.	

The highest number of juveniles appeared in a stock of *Phlox paniculata* (150 juveniles / 10 g roots). There were no symptoms in these roots. Among roses, the highest number of infections and also the highest number of nematodes per sample were found in garden roses but also 3 out of 10 stocks of multiflora roses for house plants were infected.

Root lesion nematodes

Of the two phytosanitarily important *Pratylenchus* species, *P. penetrans* occurred more commonly (Table 1), and the infections of *P. penetrans* were slightly stronger than those of *P. convallariae*. All the infections were weak, the maximum number of adults and juveniles in the roots being 50 *P. penetrans* and 35 *P. convallariae* / g roots. No visible symptoms of infections were seen. The other *Pratylenchus* species, *P. crenatus* Loof, *P. fallax* Seinhorst and *P. pratensis* (de Man) Filipjev were found in 18 plant stocks. The plant species of where *Pratylenchus* infections were found are as follows:

<i>P. penetrans:</i>	<i>P. convallariae:</i>
<i>Berberis thunbergii</i>	<i>Acer ginnala</i> Maxim.
<i>Paeonia officinalis</i>	<i>Ribes alpinum</i>
<i>Potentilla fruticosa</i>	<i>Rosa</i> sp.
<i>Ribes pallidum</i>	<i>Rubus idaeus</i>
<i>Rosa</i> sp.	
<i>Rubus idaeus</i>	<i>P. crenatus:</i>
<i>Spiraea × cineraria</i> Zabel	<i>Ajuga reptans</i>
<i>Syringa reflexa</i> Schneid.	<i>Aesculus hippocastanum</i> L.
<i>S. vulgaris</i> L.	<i>Lonicera tatarica</i>
<i>Viburnum opulus</i> L.	<i>Paeonia</i> L. sp.
	<i>Rosa</i> sp.
	<i>Ribes</i> L. sp.
<i>P. fallax:</i>	
<i>Hydrangea anomala</i> D. Don	<i>P. pratensis:</i>
<i>Thuja occidentalis</i>	<i>Convallaria majalis</i>
	<i>Rosa</i> sp.

About 40 % of the *Pratylenchus* infections occurred in the roots infected also by *Meloi-*

dogyne spp., but there were no mixed infections between the different *Pratylenchus* species. Among roses, infected stocks were found in all types of cultivars: those used for outdoor cultivation as well as those for cut flower production or for house plants.

Ectoparasitic root nematodes

Pin nematodes were found in 8 stocks: *Paratylenchus bukowinensis* Micoletzky in *Hydrangea petiolaris* and *P. projectus* Jenkins in *Cornus alba*. The stylet nematodes *Tylenchorhynchus claytoni* Steiner and *T. dubius* (Butschli) Filipjev were found in 11 stocks, including the following plant species:

<i>T. claytoni</i> :	<i>T. dubius</i> :
<i>Ajuga reptans</i>	<i>Astible</i> D. Don sp.
<i>Convallaria majalis</i>	<i>Convallaria majalis</i>
<i>Cornus</i> L. sp.	<i>Rosa</i> sp.
<i>Rhododendron</i> sp.	
<i>Ribes nigrum</i>	
<i>Rosa</i> sp.	
<i>Syringa</i> sp.	

Spiral nematodes were detected in 8 stocks, including several mixed infections of two species. *Helicotylenchus pseudorobustus* (Steiner) Golden and *H. varicaudatus* Yuen occurred as follows:

<i>H. pseudorobustus</i> :	<i>H. varicaudatus</i> :
<i>Hydrangea anomala</i>	<i>Syringa reflexa</i>
<i>Rhododendron</i> sp.	

The genus *Rotylenchus* occurred as *R. fallorobustus* (Goodey) Sher and *R. robustus* (de Man) Filipjev:

<i>R. fallorobustus</i> :	<i>R. robustus</i> :
<i>Acer ginnala</i>	<i>Astible</i> sp.
<i>Aesculus hippocastanum</i>	<i>Rhododendron japonicum</i>
<i>Astible</i> sp.	<i>Vaccinium corymbosum</i>
<i>Rhododendron japonicum</i> (A. Gray)	
Suring.	<i>R. goodeyi</i> :
<i>Syringa reflexa</i>	<i>Aesculus hippocastanum</i>

The stubby root nematodes *Trichodorus* spp. were found in four stocks: *T. primitivus* (de Man) Micotetzky in *Potentilla fruticosa* and in two stocks of *Rosa rugosa* Thumb. and *T. viruliferus* Hooper in *Hydrangea anomala*. There were too few nematodes for virus transmission test.

Discussion

The high frequency of *Meloidogyne* infections was expected on the basis of the superior international dissemination of these nematodes (SASSER 1977). Larvae of *Meloidogyne* spp. where, however, rare in the Danish nurseries and rose fields (SONDERHOUSEN et al. 1968) and equally infrequent further south (WOLNY 1980, KOZLOWSKA and WASILEWSKA 1972). The fairly high frequency of *Meloidogyne* spp. larvae in roots of this survey may have several explanations. Either the imported plant material originated from particularly highly infected areas or even from third countries, or the material was infected during preparation for exports or during transportation.

The inadequate capacity of transferred root knot nematodes to adapt to new situations (SASSER 1977) must be the reason why *Meloidogyne* infections have not been more frequent in local nurseries. In greenhouses, many species of the root knot nematodes can be expected quickly to build up injurious populations. It is therefore of major importance that attention be paid to the quality of the material. In open fields the maximum accumulated temperature in southern Finland is in most years double the temperature needed for larval development of *M. hapla* (VRAIN et al. 1978). Survival of infective populations of *M. hapla* in comparable conditions has been shown (JOHNSON and POTTER 1980). The great strain specific differences in temperature thresholds for survival demonstrated with *M. javanica* by DAULTON and NUSBAUM (1961) and the ability of SAYRE'S *M. hapla* population to tolerate freezing temperatures (SAYRE 1964) are of special concern.

The *Pratylenchus* species described above have, previously, been found in Finland (SARAKOSKI 1978). *P. penetrans* has caused injuries in greenhouse carnations, young apple trees, *Crataegus* sp. and onions (ANON. 1963—64, SARAKOSKI 1978). The low frequency of *Pratylenchus* spp. in the detected roots, in contrast to the high frequency of these nematodes in the European nurseries (SONDERHOUSEN et al. 1968), might be due to the nematodes' mobility during harvesting or storage of the plants for import. *P. penetrans* has shown properties which make it transportable (WYSS 1970), and WOLNY (1980) found quite a number of root lesion nematodes in the roots of nursery plants grown in infested soil. After all, even a weakly disseminated population might become important because of the relatively high infectivity of *Pratylenchus* species at low temperatures (FERRIS 1970, KIMPINSKI and WILLIS 1981) and because of their interactions with pathogenic fungi.

The ectoparasitic nematode species found here were mostly the same as found by WOLNY (1980). Many of them are capable of adaptation, enabling survival during transportation in roots which should be free from any loose soil. *D. myceliophagus* forms 'curds', aggregates of a cryptobiotic stage (CAIRNS 1953, PERRY 1977). *D. destructor* which is devoid of any inactive stage can, on the other hand, survive on fungal hyphae. The *Pratylenchus* species and *T. claytoni* are at a certain stage able to stay inactive and desiccated even for years (MCGLOHON et al. 1962, BRZESKI 1976). *T. dubius* has been mentioned capable of being spread by wind (SIMONS 1973), and some unidentified *Helicotylenchus* nematodes were found capable of the same (ORR and NEWTON 1971). *R. robustus* survives long pe-

riods without a host plant (SEINHORST and KENIASU 1969) and has been found fairly drought tolerant (WYSS 1970). The nematodes most sensitive to desiccation and to all disturbances are the trichodorides (WYSS 1970). *T. viruliferus* is, however, known to shield itself by burrowing into cracks it has produced in the roots (PITCHER and MCNAMARA 1970). No such behaviour has been reported about *T. primitivus*.

The introduction of the above mentioned and other new ectoparasitic species is highly probable, but establishment of injurious populations of the species is unlikely if the infections remain as weak as here described. However, severe infestations of the potato rot nematode, *D. destructor*, has been reported in southern Sweden (ANDERSSON 1967), and the nematode has a great number of hosts among Finnish plants and many universally common fungal hosts (FAULKNER and DARLING 1961). The populations of *T. dubius* are known to increase at 10°C (MALEK 1980). *R. robustus* was injurious in the Scottish forest nurseries and it has been shown to start feeding at a temperature as low as 0.5°C (BOAG 1980), but its development is very slow (BOAG 1982).

As for the *Trichodorus* species, the viruses potentially transmitted by them would indirectly make the nematodes economically very important. Neither of the two *Trichodorus* species are known in Finland, but *T. primitivus* is well distributed in Sweden (PERSSON 1968). Of the viruses concerned, the existence of tobacco rattle virus (TRV) has been reported in Finnish nurseries (TAPIO 1972), but there is no documentation on pea early browning virus (PEBV).

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SELOSTUS

Kasveille haitallisten ankerosten esiintyminen maahantuodussa taimimateriaalissa vuonna 1980

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Tutkimuksen tarkoituksena oli selvittää haitallisen ankerossaastuntojen leviämistä tuotaessa maahamme taimituotteita. Kasvieriä tutkittiin kaikkiaan 670 ottamalla jokaisesta yksi näyte. Kasvieriät olivat peräisin 42 tuontierästä. Haitallisia ankeroslajeja tavattiin 201 kasvierästä. Karanteenimääräysten alaisia lajeja löydettiin 100 kasvierästä. Nämä saastunnat keskittyivät 26 tuontierään, joista 15 erästä löytyi 3 tai useampia saastuneita kasvi-eriä.

Juuriäkämäankeroiset olivat yleisimpiä saastuntojen aiheuttajia. Niitä löytyi 40 kasvilajista ja 81 kasvierästä, 12 % tutkituista kasvieristä. Saastunnat olivat varsin yleisiä mm. happomarjapensaissa ja pioneissa. Eniten saastuntoja tuli kuitenkin avomaalle tarkoitetuissa ruusuissa, joiden tuontikin oli runsainta. Äkämäankeroissaastuntoja tuli myös äitienpäiväruusuissa, mutta leikkoruusujen 41 juurierässä löydettiin vain yksi saastunut. Eri äkämäankeroislajien esiintymisyleisyyttä ei määritetty.

Juurihaava-ankeroista, *P. penetrans*, tai sen sukulaislajia *P. convallariae* löytyi 28 kasvierästä, eli 4 %:sta tutkituista eristä. Enimmät saastunnat löytyivät ruusuista, vadmista ja happomarjapensaista. Lahoankeroista, *D. destructor*, löytyi vain yhdestä ruusuerästä.

Juurten pinnalla eläviä, sukuihin *Paratylenchus*, *Tylenchorhynchus*, *Helicotylenchus* and *Rotylenchus* kuuluvia lajeja löytyi useita, mutta varsin pieniä määriä. Kah-ta virusten levittäjänä tunnettua *Trichodorus*-suvun lajeja löytyi vain 4 kasvierästä kaikista kuitenkin niin vähän, ettei ankerosten toimintaa virusten siirtäjänä voitu tarkistaa.

Äkämäankeroisten maahankulkeutumisesta aiheutuva riski todettiin uhkaavaksi. Ainakin pohjoisimman lajin, *M. hapla*, säilyminen talven yli avomaalla on todennäköistä ja lisääntyminen mahdollista, sillä toukan kehitys vaatii alle puolet siitä lämpötilojen summasta, joka kertyy Etelä-Suomessa useimpina vuosina. Saastuntariski pahenee, jos tuotujen kasvien jatkokasvatus tapahtuu kylmältä suojattuna. Pahoilta ankerossaastunnoilta on säästyty kasviuoneviljelyksillä sen ansiosta, että leikkoruusun tuontijuuret ovat olleet tavallista taimitarhamateriaalia puhtaampia saastunnoista. Viileisiin oloihin sopeutuneena juurihaava-ankeroisen saattaa lisääntyä haitalliseksi vähäisistäkin saastuntalähteistä. Se voi tulla merkittäväksi myös levittämällä sienitauteja. Juurten pintaloisina esiintyvien ankerosten aiheuttamat saastunnat olivat niin heikkoja, ettei niillä voida olettaa olevan suurta merkitystä.

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